WESTON SOLUTIONS, INC.

**OMEGA CHEMICAL SUPERFUND SITE**
**WHITTIER, CALIFORNIA**

**PHASE 2 GROUNDWATER CHARACTERIZATION STUDY**

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WESTON SOLUTIONS

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**PHASE 2 GROUNDWATER CHARACTERIZATION STUDY**

Contract No.: DACA45-98-D-0004
Task Order No.: 0009

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Prepared for:

U.S. Environmental Protection Agency
Region IX

Prepared by:


Weston Solutions, Inc.
Suite 1000
14724 Ventura Boulevard
Sherman Oaks, CA 91403-3501

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Approved by: Carol Yuge 6-12-03

Carol Yuge, Project Manager — Date
Weston Solutions, Inc.

Approved by:

Frank Monahan, P.E., Quality Assurance/Quality Control — Date
Weston Solutions, Inc.

Approved by:

Diane Strassmaier, Remedial Project Manager — Date
U.S. Environmental Protection Agency, Region IX

Approved by:

Vance Fong, Quality Assurance Manager — Date
U.S. Environmental Protection Agency, Region IX

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# SECTION 1
# INTRODUCTION

This technical memorandum summarizes the results of the Phase 1 and 2 groundwater characterization investigations performed by Weston Solutions, Inc. (formerly Roy F. Weston, Inc. (WESTON®) at the Omega Chemical (Omega) National Priorities List (NPL) site located in Whittier, California. The Phase 1 field investigation was conducted in the summer and fall of 2001, while the Phase 2 field investigation was completed in the summer of 2002. Results of the Phase 1 investigation were documented in the Phase 1 Groundwater Characterization Study (WESTON 2002a). The groundwater investigations were conducted in support of the remedial investigation (RI) of groundwater at Operable Unit Number 2 (OU-02) of the Omega Chemical Superfund site (Omega). The purpose of this technical memorandum is to document the results of groundwater sampling and lithologic exploration and to develop a conceptual model of the hydrogeologic conditions in the OU-02 area.

This document is a deliverable under Work Assignment No. 0009 of the U.S Army Corp of Engineers (Corps) Rapid Response Contract with Roy F. Weston Inc, No. DACA45-98-D-0004, in support of the United States Environmental Protection Agency (EPA) for the OU-02 Groundwater Remedial Investigation/Feasibility Study at the Omega Chemical Superfund Site.

## 1.1 OBJECTIVES AND SCOPE

The specific objectives of the groundwater investigation include:

- Determine the nature and extent of groundwater contamination, primarily in areas downgradient of the Omega Chemical Superfund site.
- Develop a conceptual model of the hydrogeologic conditions in the OU-02 area.
- Attempt to identify other areas of potential groundwater contamination sources.

The data collected from these field investigations will assist EPA in selecting a remedy to eliminate, reduce, or control risks to human health and the environment. The overall goal is to develop sufficient data necessary to support the selection of an approach for site remediation and ultimately reach a Record of Decision (ROD) with the Responsible Parties (RPs).

The investigations documented in the technical memorandum were conducted in general accordance with the Field Sampling Plan (FSP) (WESTON, 2001) and Quality Assurance Project Plan (QAPP) (WESTON, 2001). Deviations from those procedures are described herein.

The specific scope of the Phase 1 groundwater characterization studies included the following:

- Installation of 30 Cone Penetration Test (CPT) probes for lithologic logging.
- Collection of groundwater samples from CPT borings at 80 locations.
- Laboratory analysis of groundwater samples for volatile organic compounds (VOCs).

The Phase 2 investigation focused primarily on filling data gaps in three areas:

- Greater definition of contaminant distribution and subsurface conditions near the Omega site.
- Exploration to delineate the extent of contamination in upgradient areas to the north of the Omega site.
- Explorations in the southern and southwestern part of the study area to determine the downgradient extent of the contaminant plume.

The specific scope of the Phase 2 groundwater characterization studies included the following:

- Installation of 6 additional CPT probes and 19 hollow stem auger (HSA) boring explorations for lithologic logging.
- Installation of 18 groundwater monitoring wells for monitoring purposes and for further lithologic logging.
- Collection of groundwater samples at 34 additional CPT probe and HSA boring locations.
- Laboratory analysis of groundwater samples for volatile organic compounds (VOCs).

The 18 EPA monitoring wells installed as part of this investigation have been sampled quarterly since February 2002 along with ten wells monitored by the Omega Chemical Site PRP Organized Group (OPOG). The monitoring wells were sampled for VOCs, total and dissolved metals, cyanide, perchlorate, and 1,4-dioxane. Results of the quarterly groundwater sampling of the monitoring wells were presented in a series of reports (WESTON, 2001b, 2002a). The results from quarterly groundwater monitoring have been incorporated into this report as appropriate to assist in interpretation of the Phase 1 and 2 results.

# SECTION 2
# BACKGROUND

Background information was obtained from historical documents prepared by regulatory agencies and the Omega Chemical Site PRP Organized Group (OPOG) and their consultants. This summary is reproduced from the version presented in the Phase 1 report (WESTON, 2002a), with additional discussion of the local geological conditions.

## 2.1 SITE LOCATION AND DESCRIPTION

The Omega Chemical facility is located at 12504 and 12512 East Whittier Boulevard in Whittier, Los Angeles County, California. The city of Whittier is located 12 miles southeast of the city of Los Angeles. Approximately 85,000 people reside in the city of Whittier (www.whittierch.org). The city of Santa Fe Springs is located southwest of the facility and the community of Los Nietos is included within Santa Fe Springs. Unincorporated County of Los Angeles land is present to the northwest of the Omega site as well as farther west beyond Santa Fe Springs. The Omega Chemical Superfund site is divided into two operable units (OUs): OU-01 and OU-02. OU-01 includes the Omega Chemical facility property and extends a short distance west-southwest to Putnam Street. The OU-02 study area encompasses the area surrounding the Omega Chemical facility and extending approximately 2.2 miles to the southwest. A site location map and site features map are presented in **Figures 1** and **2**, respectively.

The facility operated as a RCRA solvent and refrigerant recycling and treatment facility, handling primarily chlorinated hydrocarbons and chlorofluorocarbons for 15 years, from approximately 1976 to 1991. Drums and bulk loads of waste solvents and chemicals from various industrial activities were processed to form commercial products. Chemical, thermal and physical treatment processes were believed to have been used to recycle the waste materials. Although the mechanism by which contaminants were released to the subsurface is not known, the release is well established by detection of elevated contaminant concentrations continuously from near ground surface to groundwater at the Omega site.

## 2.2 TOPOGRAPHY

The Omega Chemical facility is situated near the base of the gentle La Habra piedmont slope descending from the southwestern flank of the Puente Hills, at an elevation of approximately 220 feet above mean sea level (MSL). The piedmont slope descends toward the southwest at approximately 2.5 percent to a point approximately 2,800 feet southwest of the Omega Chemical facility. At this point, the ground surface flattens into a broad basin or plain, at an elevation of approximately 150 to 155 feet MSL. In the southwestern part of the study area, the ground surface ascends a low rise at the northwest end of the Santa Fe Springs plain, at an approximate elevation of 160 feet MSL. From there, the ground surface resumes a gentle southwestward slope, reaching approximately 145 feet MSL near the location of the Phase 2 boring farthest from the Omega site.

Topography in the area is shown on the Site Location Map (**Figure 1**), which is referenced to the USGS Whittier Quadrangle, and the elevation contours have also been plotted on **Plate 1**.

A small, channelized drainage, the Sorenson Avenue Drain, flows across the basin toward the southeast from a point near the intersection of Dice Road and Slauson Avenue. This channel bends toward the south beyond the limits of the study area to become La Canada Verde Creek, which cuts through a low gap between the Coyote Hills on the east and the Santa Fe Springs plain on the west. The approximate locations of the La Habra piedmont slope, Santa Fe Springs plain, and main drainages are shown on **Figure 2.**

## 2.3 REGIONAL GEOLOGICAL AND HYDROGEOLOGICAL SETTING

This discussion on the geology in the region is largely based on Bulletin 104 by the California Division of Water Resources (CDWR, 1961).

The Omega site and study area are located in the Montebello Forebay area of the Coastal Plain of Los Angeles County. The Coastal Plain is bounded on the west and south by the Pacific Ocean and by mountainous uplifts on the north, east and southeast. The Coastal Plain is underlain by an extensive groundwater basin in Los Angeles and Orange Counties.

The known water-bearing sediments in the Whittier area extend to a minimum depth of 1,000 feet below the ground surface. The identified geologic units include Recent alluvium, the Upper Pleistocene Lakewood Formation and the Lower Pleistocene San Pedro Formation. **Figure 3** shows a generalized stratigraphic column of water bearing sediments in the Whittier area.

Based on the geologic maps provided in CDWR (1961), the uppermost unit in the vicinity of Omega site consists of the "Bellflower aquiclude." The Bellflower aquiclude is defined as all the fine-grained sediments that extend from the ground surface down to the first aquifer. The Bellflower aquiclude consists primarily of clay and sandy clay to silt, and ranges from 20 to more than 60 feet in thickness in the area. CDWR (1961) includes the Bellflower aquiclude in both the Recent alluvium and the upper part of the Upper Pleistocene Lakewood Formation. In the Whittier area, the Bellflower aquiclude is assigned mainly to the Lakewood Formation except where the fine-grained sediments overlie the Gaspur aquifer (described below) and the uppermost portion of the aquifer within the basin, where the Bellflower aquiclude is assigned to Recent alluvium. Water-bearing zones locally occurring within the Bellflower aquiclude are referred to collectively and informally as the Semiperched aquifer.

In addition to the fine-grained Bellflower aquiclude, the Recent alluvium also includes a coarse-grained unit known as the Gaspur aquifer. Based on aquifer maps contained in CDWR (1961), the Gaspur aquifer is depicted occurring as an embayment within the western one-half of the study area. The south side of the embayment containing the Gaspur aquifer appears to be constrained by the uplifted Santa Fe Springs plain, which comprises the surface expression of the Santa Fe Springs anticline located along the southernmost portion of the study area. However, lithologies observed in borings advanced during the Phase 2 study suggest that the Gaspur aquifer is restricted to the far western end of the study area, along the northwest side of the Santa Fe Springs plain (see Plate 1). In the Whittier area, the Gaspur aquifer is described as sand and gravel with a little interbedded clay, and ranging to more than 80 feet in thickness. Cross-sections in CDWR (1961) indicate that the Gaspur aquifer is locally in contact with the Bellflower aquiclude and with other aquifers along an erosional unconformity, which forms a steep surface at the edge of the Gaspur deposit. Cross sections prepared for this report have been similarly interpreted (see cross-section G-G', central left side; and cross-section H-H', left end).

The Lakewood Formation consists of non-marine deposits of Late Pleistocene age and attains a maximum thickness of 70 feet in the Whittier area. The Gage aquifer is the major water-bearing member and comprises the basal lithologic unit of the Lakewood Formation. It consists of about 20 to 40 feet of sand with some interbedded clay. Based on previous investigation at the Omega Chemical site, the Gage aquifer appears to be absent beneath the Omega site itself (England-Hargis, 1996b,c). A sand interval observed in explorations a short distance southwest of the site is believed to correlate with the Gage aquifer (England- Hargis, 1996b,c). The explorations conducted during the two phases of this investigation also suggest that the Gage aquifer is present west of the Omega Chemical site and both narrows and pinches out towards the east. The Gage aquifer does not appear to be an important source of drinking water in the Whittier area, because of elevated TDS concentrations that have been observed during previous sampling, and it further appears that none of the local water supply wells have been completed in this aquifer. Aquifer maps in CDWR (1961) depict the Gage aquifer being absent in a tongue that trends west-southwest from a point approximately 3,000 feet west of the Omega Chemical facility. The Gage may have been eroded away in that area in connection with deposition of the Gaspur aquifer sediments.

Underlying the Lakewood Formation are continental and marine sand and gravels with interbedded clay, assigned to the San Pedro Formation. The San Pedro Formation reaches a maximum thickness of 850 feet and extends to a depth of about 920 feet in the Whittier area. The San Pedro Formation unconformably underlies the Lakewood Formation. This unit has been folded across structures including the La Habra syncline, the Santa Fe Springs syncline, and along the south flank of the Puente Hills. The lower part of the San Pedro Formation crops out along the edge of the Puente Hills east-southeast of the Omega site. The San Pedro Formation has been subdivided into five named aquifers separated by clay members (CDWR, 1961). A fine-grained layer is also typically present at the top of the sequence, although in localized areas, the uppermost San Pedro Formation aquifer may be merged with the overlying aquifer, and one or more of the five aquifers are also merged in some locations.

The five aquifers defined within the San Pedro Formation include, from top to bottom, the Hollydale, the Jefferson, the Lynwood, the Silverado, and the Sunnyside. The uppermost aquifer is less extensive than the others and appears to be absent immediately beneath the Omega Chemical facility, based on the aquifer maps in CDWR (1961, Plates 14, 15, 16, 17, 18A, 19A, 20A, 21A, 22, and 23). Aquifer thickness within the San Pedro Formation generally increases with depth. Occurrence of these aquifers in the Whittier area is described in "Chapter VI, Description of Groundwater Basins, Central Basin, Geologic Features of the Whittier Area," in CDWR (1961).

Aquifer maps in CDWR (1961) indicate the Hollydale aquifer is present within the southwestern approximately two-thirds of the study area. The Hollydale is reported to be 10 to 25 feet in thickness in the Whittier area, and comprised of sand and gravel with interbedded clay. The Hollydale aquifer is believed to be merged with the overlying Gage aquifer in the southeastern part of the study area.

The Jefferson aquifer is depicted in CDWR (1961) as extending as far northeast as Whittier Boulevard (i.e., underlying the Omega site). The Jefferson aquifer is described as sand with some gravel and a little interbedded clay, and is approximately 20 to 40 feet in thickness. The Jefferson and Hollydale aquifers are reported to be merged to the northwest of the study area.

The Lynwood and Silverado aquifers extend northeast beyond the Omega site to the upper portion of the piedmont. The Lynwood aquifer is described as 50 to 100 feet of sand and gravel with some interbedded clay, while the Silverado aquifer is comprised of approximately 100 to 200 feet of sand and gravel. The Lynwood aquifer is merged with the overlying Jefferson aquifer along a narrow strip northwest of the study area.

The Sunnyside aquifer extends to the southwest edge of the Puente Hills northeast of the Omega site. The Sunnyside aquifer ranges from approximately 200 to 300 feet in thickness and is comprised of sand and gravel with interbedded clay. The sediments of both the Silverado and Sunnyside aquifers are exposed along the south flank of the Puente Hills approximately two miles to the east-southeast of the Omega site.

The Pliocene and Miocene marine sediments and sedimentary bedrock below the San Pedro Formation generally contain saline water in the area, but locally contain freshwater. These units are considered non-water bearing where exposed in the Puente Hills and include the Pliocene Pico and Repetto Formations and the Upper Miocene Puente Formation.

The major geologic structures in the area include a homocline that underlies the La Habra piedmont slope, the northwest-trending La Habra syncline underlying the alluvial basin, and the west-northwest- trending Santa Fe Springs anticline, which is situated beneath the slightly uplifted Santa Fe Springs plain. The Whittier fault is also present nearby to the northeast of the site, trending west-northwest across the southern side of the Puente Hills. Folding is generally better developed in the older and deeper lithologic units. The traces of the La Habra syncline and Santa Fe Springs anticline are shown on **Plate 1**, adapted from Plate 3A of CDWR (1961).

The La Habra syncline is located between the Puente Hills on the north and the Santa Fe Springs/Coyote Hills uplift on the south. The La Habra syncline ends toward the east against the East Coyote anticline, and fades out toward the northwest at an apparent subsurface saddle. The La Habra syncline affects the San Pedro Formation and, to a lesser extent, the Lakewood Formation sediments, and has surface expression as the axis of the basin.

The Santa Fe Springs anticline consists of a broad dome, and has folded both the San Pedro and Lakewood formation sediments. Shallow aquifers thin across the crest of the anticline, but groundwater movement is not otherwise believed to be affected.

## 2.4 OMEGA SITE GEOLOGY AND HYDROGEOLOGY

The geology of the Omega site and immediate vicinity has been explored with a series of soil borings and CPT explorations previous to this investigation. The location of historical borings near the site is shown in **Figure 4**. Other borings and soil gas probes installed at the Omega facility are not depicted; however, the previous explorations at the Omega site are discussed and depicted in England-Hargis (1996a, b, c) and in CDM (2001b). The Omega site is underlain by low permeability silty and clayey soils to a depth of at least 120 feet. No significant water producing sand units have been found directly beneath the Omega site in any of the explorations. A sand unit believed to correlate with the Gage aquifer has been encountered a short distance southwest of the Omega site (England- Hargis, 1996b,c).

Groundwater beneath the Omega Chemical site occurs at approximately 70 feet bgs. Locally, groundwater flow appears to be generally toward the southwest. CDM (1999) reported a local direction of groundwater flow toward the southwest with a hydraulic gradient of 0.009 ft/ft. Total dissolved solids (TDS) concentrations of greater than 3,000 mg/L were reported in shallowest groundwater samples by CDM (1999).

The hydraulic conductivity has been estimated from a slug test at well OW-1 and step-drawdown tests conducted in monitoring well OW-2. The respective hydraulic conductivity based on testing in these two locations was found to range from 0.6 to 1.6 feet per day. Well OW-1 is screened in saturated silt and clay of the Bellflower aquiclude, while OW-2 is screened primarily within sands of the presumed Gage aquifer. K

## 2.5 WATER SUPPLY WELLS

Based on a review of England-Hargis (1996c), there are 6 water supply wells within 1.5 miles of the site **(Figure 4)**. The nearest well (02S/11W-30R3, also know as Santa Fe Springs Well No. 1) is located 1.3 miles to the west-southwest of the former Omega Chemical facility. The well is screened at 200 to 288 feet bgs and again from 300 to 900 feet bgs. Trichloroethene (TCE) (0.7 ug/L) and chloroform (1.3 ug/l) were detected in water samples from the well in October 1994. The Los Nietos water supply well (02S/11W-30Q5) is located about 1.5 miles west-southwest of the site. This well is screened from 152 to 370 feet bgs. Tetrachloroethene (PCE) and TCE were detected at unspecified concentrations in 02S/11W-30Q5 in 1986-90. The remaining wells are no longer operating, are used for irrigation, or no data was available.

The Santa Fe Springs No. 1 (SFS No.1) production well is the prime receptor in the OU-02 study area with respect to potential routes of human exposure to the affected groundwater. This well is located along the northwestern central side of the study area, at the Santa Fe Springs Fire Station on Dice Road near Burke Street. This well is perforated at depths 200 to 288 feet bgs and from 300 feet to the total depth of 900 feet bgs. Aquifers that are tapped by SFS No. 1 are believed to include the Silverado and Sunnyside aquifers, which occur within the lower part of the Lower Pleistocene San Pedro Formation.

In several years of monitoring SFS No. 1, low concentrations of chlorinated hydrocarbons including TCE, chloroform, and PCE have been detected at times. TCE and chloroform have been reported most frequently, while PCE has been reported on fewer occasions, and at lower concentrations. In the most recent sampling of SFS No. 1 in February 2003, the only VOC detected was TCE, at a concentration of 0.64 ug/L. Chloroform and PCE were not reported above the detection limit of 0.5 ug/L. Hexavalent chromium was reported at a concentration of 2.6 ug/L. The depth interval(s) from which most of the contamination may be entering the well are not established.

The production rate of SFS No. 1 ranges to approximately 1,250 gallons per minute (England-Hargis, 1996c). It is not established what affect, if any, there may be on groundwater flow directions and contaminant migration within the shallowest aquifers. Based on depth to water measurements in monitoring wells east of SFS No. 1, the gradient appears to be more southerly in the upper aquifer in the vicinity, which is not consistent with the presence of a cone of depression centered around the well.

## 2.6 PREVIOUS SITE INVESTIGATIONS

A series of soil gas, soil and groundwater investigations have been performed at the Omega Chemical site by a variety of consultants beginning in 1985. A removal action was completed at the Omega site in September 1995, during which more than 3,000 drums, as well as other containers and debris, were removed from the site. In addition, both structural and process equipment surfaces were decontaminated.

Subsequent to the removal action, EPA entered into a Consent Decree on February 28, 2001with a number of potentially responsible parties collectively referred to as OPOG. The Statement of Work of the Consent Decree required OPOG to design and implement a groundwater containment and mass removal treatment system in the Phase 1a Area, which corresponds to OU-01. OPOG was further directed to conduct a vadose zone Remedial Investigation/Feasibility Study (RI/FS) for contaminant releases on, at or emanating from the Omega Chemical Property, and to install three "sentinel" groundwater monitoring wells and sample quarterly for one year at locations downgradient of the Phase 1a Area and upgradient of water supply well 2S/11W-30R3 (Santa Fe Springs Well No. 1).

OPOG began additional investigation activities in November 1995. A summary of the investigation results is provided below. Data from the investigations are presented in reports and memorandums by England & Hargis (1996a, b, c), a report by $C_2$REM (1997), and reports by Camp Dresser & McKee (1999, 2001a and 2001b).

- Shallow soil and soil-gas sampling at the Omega facility indicated that halogenated VOCs were present in site soils. The primary contaminants detected include tetrachloroethene (PCE), trichlorofluoromethane (Freon 11), and trichlorotrifluoroethane (Freon 113). PCE concentrations in soil ranged to 510 mg/kg. Soil samples from deeper intervals collected during installation of a groundwater monitoring well (OW-1) on the Omega site also contained PCE, Freon 11, and Freon 113, as well as trichloroethene (TCE), 1,1-

dichloroethene (1,1-DCE), 1,2-dichloroethane (1,2-DCA), and 1,1,1-trichloroethane (1,1,1-TCA).

- Three phases of direct push groundwater sampling were conducted at the Omega site, in the immediate vicinity, and downgradient. The farthest sampling location was approximately one mile west-southwest of Omega. Concentrations of PCE and Freon 113 as high as 86,000 ug/L and 7,500 ug/L, respectively, were detected in groundwater beneath and a short distance downgradient of the Omega site. Lower concentrations of PCE in the 9ug/L to 580 ug/L range were detected nearby upgradient as well as farther downgradient from Omega.

- Ten groundwater monitoring wells were installed in five phases from 1995 to 2001. These wells are sampled by OPOG semiannually and are also sampled by WESTON as part of quarterly monitoring of the EPA OU-02 wells. Locations of the OPOG wells are included on **Figure 5** and **Plate 1**, and the total drilled depths and screened intervals for each are listed in **Table 1.** The highest concentrations of contaminants have been detected at OW-1, with PCE ranging to 86,000 ug/L and Freon 113 to 1,400 ug/L. PCE in OW-8 ranges to 14,000 ug/L. PCE concentrations at OW-2 and OW-3 have ranged from 620 ug/L to 2,100 ug/L. PCE concentrations at OW-4A have shown variability since monitoring began there in 2001. In May and August of 2001, PCE concentrations of 1,000 ug/L and 1,300 ug/L, respectively, were reported (CDM, 2002, Table 1-1). In November 2001, the detected PCE concentration dropped to 9.8 ug/L, and in February 2002, the reported PCE concentration was 130 ug/L (CDM, 2002, Table 1-1). In May 2002, the reported PCE concentration was 20 ug/L (WESTON, 2003). The overall trend at OW4A since monitoring began appears to be an unsteady decline in concentrations. The variability could reflect inhomogeneity in the contaminant concentrations within the migrating groundwater mass. In the first two quarters of 2002, PCE results for deeper well OW-1B ranged from about 30 to 190 ug/L and for OW-4B ranged from 2 to 28 ug/L (WESTON, 2002b, 2003). Concentrations of PCE reported for well OW-6 have ranged from approximately 25 to 150 ug/L, and at OW-5 are approximately 150 ug/L.

# SECTION 3

## FIELD INVESTIGATION METHODOLOGY

The field investigation documented in this memorandum consisted of the following general tasks:

- CPT explorations,
- Hollow stem auger boring explorations,
- Drilling and installation of EPA OU-02 monitoring wells,
- Groundwater sampling,
- Laboratory analysis of groundwater samples,
- Surveying.

The Phase 1 field investigations were conducted between August and November 2001. The field investigation was conducted in three sampling efforts and is summarized below.

- Completion of 30 CPT explorations (PP001, -002, -006, -010, -011, -013, -015, -017, -020, -022, -023, -029, -033, -034, -038, -039, -040, -041, -042, -046, -052, -057, -059, -063, -065, -066, -069, -070, -074, and -081).
- Collection of 81 push probe groundwater samples (PP001 through PP085). Originally proposed locations PP005, PP027, PP028, PP029, and PP031 were omitted or relocated, primarily due to their locations being outside the contaminant plume as defined during the investigation. At that time, PP005 was omitted due to data being available from other nearby sample locations, although sampling was subsequently conducted at that location during the Phase 2 investigation. PP027 was relocated and assigned a new identification (PP075). PP028 was omitted due to utility conflicts.
- GPS surveying of push probe locations.

The 18 EPA OU-02 monitoring wells were drilled and installed in December 2001 and have been sampled on a quarterly basis since then. The Phase 2 sampling was conducted from 5 August to 14 August 2002. The Phase 2 field investigation is summarized below.

- Completion of 6 CPT explorations (PP091, -092, -094, -095, -112, and -115).
- Completion of 19 hollow stem auger (HSA) borings (B086, -087, -088, -089, -090, -096, -097, -098, -099, -100, -101, -102, -103, -104, -105, -107, -108, -109, and –110).
- Collection of 34 groundwater samples (B086 through B090, PP091 through PP095, B096 through B105, PP106, B107 through B110, and PP111 through PP119).
- Land surveying of EPA well locations and elevations, and GPS surveying of Phase 2 exploration locations.

This section presented a summary of the field efforts by task, including the number and location of samples and sampling and analytical procedures. All work was conducted in general accordance with the FSP (WESTON, 2001a) and QAPP (WESTON, 2001b) submitted to and approved by USACE and EPA.

Originally, approximately 100 groundwater sampling locations and 25 CPT locations had been planned, with 40 provisional locations initially selected to provide coverage in accessible areas downgradient (west-southwest) of the Omega site at a spacing of approximately 500 to 1,000 feet between sample points. As the contamination plume was followed during the Phase 1 exploration, provisional locations determined to be beyond the limits of the contiguous plume (i.e., at or below concentrations of 5 ug/L) were omitted. The area to be explored was originally intended to extend only approximately 7,000 feet from the Omega site, to the vicinity of public supply well 2S/11W-30R3 (Santa Fe Springs Well No. 1). However, persistent detections across the southern part of the planned area of exploration prompted establishment of additional sampling points to the south. Other sample locations were added to better define plume boundaries and clarify observed concentration trends and variances. After completion of the Phase I investigation, the contaminant plume still could not be completely defined on the south to concentrations below approximately 50 ug/L. The presence of railroad right-of-way and large private tracts in the area where the southern plume boundary was anticipated to occur precluded access for sampling along this margin of the plume as then estimated.

The 18 EPA OU-02 monitoring wells were established generally in the locations and depths as planned in the Phase 1 investigation report (WESTON, 2002a). The monitoring wells were sited so as to be able to monitor groundwater concentrations over time in locations near the margins of the plume and along the approximate axis of the plume, as it was understood based on the Phase 1 results. During the Phase 2 investigation, additional data were collected to address data gaps in three areas: provide greater definition of contaminant distribution and lithologic conditions near the Omega site; constrain the upgradient limit of detectable contamination in areas north of Omega; and, locate the approximate downgradient extent of the contaminant plume.

### 3.1 CPT EXPLORATIONS

Thirty-six (36) CPT geophysical explorations for lithologic logging were completed at the locations noted in **Table 1** ("Lithology = CPT-X") and are included on **Figure 5**. The exploration and sampling locations are labeled using a prefix that incorporates the type of exploration ("PP" for push probe) followed by a sequential number (i.e. PP001). The CPT geophysical exploration identification matches the groundwater sample identification. The CPT borings were completed at depths ranging from 35 to 107 feet bgs. A summary of the CPT sample depths is provided in **Table 1**. The CPT records are presented in **Appendix A**.

The CPT explorations were completed using equipment owned and operated by Gregg In-Situ, Inc. of Signal Hill, California. The CPT equipment uses an electronic cone penetrometer apparatus attached at the tip of a string of steel rods. The rods are advanced using a truck-mounted CPT rig. The weight of the truck is brought to bear on the rod and cone tip, driving the cone tip through the subsurface soils. As the rod is advanced, the cone sensor transmits physical parameters to be recorded and interpreted by an on-board computer including tip resistance or cone bearing, sleeve friction, and dynamic pore pressure, at 5 cm intervals. The on-board computer plots the key parameters and generates an interpreted stratigraphic log for the borings. Lithologic interpretations are based on relationships between these three parameters, especially the sleeve friction to cone bearing ratio, which provides the friction ratio. Soil classification using CPT data was based on empirical correlations documented in Robertson and Campanella (1989). Logs providing the results of the automated CPT logging and the corresponding lithologic interpretations were provided by Gregg In-Situ, Inc.

In most locations where CPT geophysical logging was conducted, a pore pressure dissipation (PPD) test was conducted to measure the groundwater pressure head and estimate the groundwater depth relative to the penetration depth in lieu of sounding. The results of the pore pressure dissipation tests are included with the CPT logs in **Appendix A**.

All direct push borings were abandoned by backfilling with grout made with water, Portland cement and approximately 5 percent bentonite gel, using a support truck dedicated for that purpose. A hollow rod or PVC pipe was placed back into the hole for use as a tremie pipe. The grout was pumped through the tremie pipe, filling the boring from the bottom up. The tremie pipe was withdrawn in stages as the boring filled, to avoid either free-fall of grout into water, or grouting of the tremie pipe in the hole. Once the grout reached the surface, it was allowed to settle for approximately one hour or more. The hole was topped off to within approximately six inches of the surface, and rapid-set concrete or asphalt cold patch was used for surface repair, to match the existing surface.

## 3.2 HOLLOW STEM AUGER EXPLORATIONS

Nineteen (19) explorations were completed using hollow stem auger drilling techniques for lithologic logging and groundwater sampling at the locations shown in **Figure 5**. The hollow stem auger boring locations are labeled using a prefix that incorporates the type of exploration ("B" for boring) followed by a sequential number (i.e. B086). The hollow stem auger borings were completed to depths ranging from 55 to 102 feet bgs. A summary of the hollow stem auger boring groundwater sampling depths is provided in **Table 1**. Copies of the exploration boring logs are presented in **Appendix B**.

Drilling and soil sampling were generally conducted as described for hollow stem auger drilling in Section 3.3. Soil samples were typically collected at five-foot depth intervals using a split spoon sampler until near groundwater, when continuous sampling was begun. Groundwater sampling from hollow stem auger borings is described in Section 3.4. Exploratory borings were abandoned upon completion using either Portland cement and bentonite grout pumped downhole or hydrated bentonite chips. Borings were patched at the surface with rapid-set concrete or asphalt cold patch to match surrounding surfaces.

## 3.3 MONITORING WELL INSTALLATION

Eighteen (18) monitoring wells were drilled and installed at the locations shown in **Figure 5**. Locations within the City of Whittier were established in street rights-of-way. Wells sited within the City of Santa Fe Springs were located within "parkway" areas of City property adjoining the street. The well locations are labeled using a prefix that incorporates the type of exploration ("MW" for monitoring well). The prefix is followed by a sequential number (i.e. MW09) and a suffix "A" through "D" denoting the relative depth to the screened interval ("A" is used for the shallowest wells in the network). The EPA OU-02 monitoring wells were completed at total depths ranging from approximately 35 to 120 feet bgs. A summary of the monitoring well screen depths is provided in **Table 1**. Copies of the lithologic logs and monitoring well construction details are presented in **Appendix C**.

The drilling and well constructions were completed using equipment owned and operated by Gregg Drilling & Testing, Inc. of Signal Hill, California. Shallower wells were drilled using hollow stem auger techniques, whereas the deeper wells were installed using mud rotary drilling techniques.

Most of the wells were sampled during drilling using continuous coring methods to obtain as much detailed lithology as possible. Some borings were sampled using a split-spoon sampler either continuously or at five-foot depth intervals. Soils were logged by the field geologist working under supervision of a State of California registered geologist. Lithology was described in accordance with the Unified Soil Classification System (USCS). Soil from approximate five-foot intervals was screened for emission of organic vapors using a photoionizing detector (PID). A small amount of soil was placed in a reclosable plastic bag and vapors from the soil were allowed to collect in the headspace within the bag. The probe of the PID was then quickly inserted into the bag, and the reading was measured and recorded on the field log along with the lithologic description and the relative sample recovery. The relative soil sample recoveries and PID readings are included on the logs of the monitoring wells in **Appendix C.**

Copies of the monitoring well logs and well construction details are included in **Appendix C**. On the logs, contacts between lithologies are depicted as a dotted line at the depth where observed within a sample core. Contacts not seen (i.e., lithologic change occurred between samples or recovered portions) are depicted as a dotted line approximately between the depths where soils were recovered. Further, the USCS convention of "SW," referring to a well-graded sand, has been applied to denote fine to coarse sands encountered that may not meet the strict definition of the USCS "SW."

For hollow stem auger drilling, the hole was reamed with 10-inch outside diameter augers after completion of the pilot boring. A wood plug was placed into the lead auger to keep the inside of the augers free of loose soil. When the boring had been reamed to the target screen depth, the wood plug was knocked free using the downhole hammer and the well screen and casing were placed into the augers. Sand and sealing materials were slowly placed into the annular space as augers were removed. Before placement of the seal above the sand pack, a surge-block was used down casing to consolidate and settle the sand pack.

Where mud rotary drilling was conducted, the mud was thinned if necessary, the pipe and bit were withdrawn from the boring after reaching the target depth, and the well screen and casing were placed directly into the hole. Sand pack and sealing materials were allowed to fall through the mud and settle into place. The grout was pumped through a hose placed downhole.

Four-inch diameter well screen and casing materials were placed at most locations. However, two-inch diameter well screen and casing materials were used for nested wells completed in the same borehole at MW04B/C and MW08B/C. Where the pilot hole was drilled deeper than the well screen was placed, the boring was backfilled with bentonite chips or pellets up to the desired level of the well bottom prior to installation. This procedure was followed at wells MW01B, MW03A, MW04C, MW08D, and MW09A. After the final grout was placed and allowed to settle, the monitoring wells were completed at the surface with a traffic-rated well box set in rapid-set concrete. Well construction materials and depths of emplacement are shown on the monitoring well logs in **Appendix C**. Screened intervals for the monitoring wells are also provided in the Summary of Exploration Data in **Table 1**.

A minimum of three days following installation, the monitoring wells were developed to remove fines or residual drilling mud by a combination of bailing, surging by swabbing across the saturated screen interval, additional bailing, and pumping. A minimum of ten casing volumes of water were removed from each well during development. Selected water quality parameters including temperature, pH, and specific conductance were monitored for stabilization tendencies while pumping the wells. Records of well development are included in **Appendix D**. After completing development, dedicated bladder pumps were installed in the wells. The pump intakes were typically placed approximately five feet above the bottom of the well. The dedicated pumps are utilized for low-flow groundwater sampling during the periodic monitoring events.

### 3.4 GROUNDWATER SAMPLING PROCEDURES

Groundwater samples were collected at one hundred fifteen (115) locations shown in **Figure 5**. No water samples were collected at 5 initially proposed locations during the Phase 1 investigations due either to refusal before the water table was encountered or the formation would not produce a water sample. Groundwater samples were collected using a temporary PVC well screen. Groundwater samples were collected at depths ranging from 33 to 101 feet bgs. The groundwater sample depths are summarized in **Table 1**. Field sampling records are included in **Appendix E**.

The FSP specified that groundwater sampling would be accomplished using either a HydroPunch type device, or with temporary well screens and casing. The latter method was employed in a few locations where groundwater yield was very poor in order to obtain a sample volume and in most of the hollow stem auger borings. Most of the CPT borings utilized a section of one-inch diameter temporary PVC well screen attached to a disposable cone tip and fitted to the drive head. The screen was typically five feet in length and was cut with 0.010-inch slots. Where fine-grained lithologies predominated and groundwater yield was slow, a second or third five-foot section of screen was added, to increase the yield. The sampler was advanced to the desired sampling depth or to refusal. The cone tip was disengaged and the rod was withdrawn to within approximately one foot of the top of screen. This exposed the boring sidewall adjacent to the screen, while higher intervals were sealed off by the hollow rod. For sampling using the hollow stem auger rig, a one-inch diameter temporary well screen and casing was placed into the augers, which were lifted four feet or more to expose the boring sidewall. The sample depth was recorded at the approximate midpoint of the exposed screen interval for both types of borings.

A decontaminated, stainless steel bailer or new, disposable acrylic bailer was carefully lowered to near midpoint of the screened interval so as to minimize disturbance of the sample and possible loss of volatiles. Once filled, the bailer was smoothly and rapidly retrieved to the surface. The sample was decanted from the bailer into the sample containers.

A photoionizing detector (PID) was used to screen the top of the hollow CPT rod or augers for organic vapors after collecting the sample at most locations. The readings are summarized in **Table 1**. Readings suspected to be inaccurate such as very highly elevated values likely attributable to excessive moisture are not listed. Before abandoning the sample boring, the depth to water was sounded using an electronic water level indicator. Where groundwater was observable during drilling of the hollow stem auger borings, depth to water where encountered was estimated as well. The recorded depth to water measurements from the soundings or PPD estimates are summarized in **Table 1.**

The water samples were labeled, placed in resealable plastic bags, and placed on ice in a chilled cooler. For the on-site field laboratory samples were logged on a chain-of-custody form at the time the samples were hand delivered. For samples that went to off-site analytical laboratories, the samples were carefully packed in ice and shipped, accompanied by the chain-of-custody documentation.

## 3.5 FIELD AND LABORATORY ANALYSIS

A total of 140 groundwater samples were submitted for laboratory analysis, including 115 groundwater field samples, 12 duplicate groundwater samples, 6 VOC trip blanks and 7 equipment rinsate blanks. Nomenclature for identification of samples followed the scheme described in the FSP. Sample names included three components separated by a dash (-) that correspond to media code/sampling period, station identification, and sample depth or type, as described below:

- The media code/period included "GW" for groundwater and three digits for the quarter and year sampled (example: GW302, signifying groundwater sampled during the third quarter of 2002.
- The station identifier included "PP" for push probe or "B" for boring, and a three digit unique number for each location (example: PP083)
- The final four digit sequence includes a first digit indicating the sample type (0 for the primary field sample, 1 for field duplicate, 2 for VOC trip blank, and 4 for equipment rinsate blank), and three digits indicating depth for field samples and duplicates or a sequential number for the other field quality assurance/quality control (QA/QC) samples (examples: 0080 signifies primary field sample from 80 feet bgs; 1080 signifies the associated duplicate sample from 80 feet bgs; 4002 signifies the second equipment rinsate blank prepared for the sampling event).

Duplicate samples were collected sequentially following the respective primary field samples, at a frequency of 10 percent of field samples. The VOC trip blanks were prepared in the field by filling sample bottles with deionized water, which were stored with the field samples and submitted with each cooler of samples shipped to off-site laboratories. Rinsate blanks were prepared by pouring deionized water in and through decontaminated or new sampling equipment and collecting the rinsate in the sample containers. Rinsate blanks were collected at a frequency of 5 percent of field samples.

Analysis was performed by a combination of off-site laboratories and the EPA Region 9 mobile Field Analytical Support Project (FASP) laboratory.

The water samples were analyzed using a combination of an EPA-ESAT Field Analytical Support Project (FASP) laboratory and off-site EPA Region 9-affiliated contract laboratories. The water samples collected during the Phase 1 investigation not analyzed by the mobile FASP laboratory were analyzed by the EPA Region 9 laboratory in Richmond, California or EMAX Laboratory in Torrance, California. Samples analyzed in the on-site lab were collected in vials that were either unpreserved or preserved with hydrochloric acid. Samples analyzed at off-site laboratories were all preserved with hydrochloric acid. At least 3 sample containers were filled. The sample vials were filled to a protruding meniscus and the lids were snugly attached. The vials were inverted and lightly tapped to check for bubbles; if none were observed larger than 2 mm in diameter, the bottle was deemed acceptable for submission to the laboratory. The water samples were analyzed for VOCs by EPA Method 8260B. Compounds reported in the analyses include tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cis-DCE), 1,1-dichloroethene (1,1-DCE), trichlorofluoromethane (Freon 11) and trichlorotrifluoroethane (Freon 113) A summary of the groundwater analytical data for the primary compounds of concern is presented in **Table 2**. A summary of all the analytical data is included as **Appendix F**. A statistical summary of the data is included as **Table 3**. The total number of samples indicated in **Table 3** (127) reflects the 115 field samples plus the 12 duplicate samples.

### 3.6 SURVEYING

The push probe locations were recorded by WESTON using global positioning system (GPS) techniques, employing Pathfinder Pro XR and Pro XRS GPS instruments. The GPS survey data is provided in **Table 4**. Horizontal locations were recorded in California State Plane coordinates with a horizontal accuracy of plus or minus one to two meters and ground surface elevation accuracy of plus or minus three to six meters. Vertical elevations from the GPS survey were not considered reliable because of the relatively poor accuracy of the elevation values. For construction of cross section profiles and the summary in **Table 1**, normalized elevations interpolated from USGS topographic contours were assigned to the sample points, due to the variability in the elevation values obtained with the GPS.

The monitoring wells were surveyed for location and elevation by a licensed land surveyor (Cabrinha, Hearn and Associates [Cabrinha]). The datum for the horizontal coordinates is the California State Plane Zone 5. Vertical coordinates (elevation) correspond to the NAVD 1988 (2000 adjusted) datum. Both horizontal and vertical coordinates were recorded to 0.01 foot. The OPOG wells were surveyed by another surveyor, referencing a different elevation benchmark and datum (NAVD 1988, 1990 adjusted). In order to resolve differences in elevation between the EPA wells and the OPOG wells for plotting of groundwater gradient, Cabrinha was contracted to survey both benchmarks and wells MW01A, MW01B, MW02A, OW4A, OW4B, and OW5, using the NAVD 1988 (2000 adjusted) datum. Elevations differences were found to range from 2.18 to 2.22 feet; therefore, the elevations for the OPOG wells have been adjusted upward 2.2 feet in **Table 1**, for calculation of groundwater elevations on the gradient map **(Figure 6)**, and for preparation of the cross sections **(Plates 2 and 3)**.